

A FRAMEWORK FOR IMPLEMENTING DATA SERVICES IN MULTI-SERVICE MOBILE SATELLITE SYSTEMS

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ABSTRACT

Mobile satellite systems being planned for introduction in the early 1990's are expected to be invariably of the multi-service type. Mobile Telephone Service (MTS), Mobile Radio Service (MRS), and Mobile Data Service (MDS) are the major classifications used to categorize the many user applications to be supported. The MTS and MRS services encompass circuit-switched voice communication applications, and may be efficiently implemented using a centralized Demand-Assigned Multiple Access (DAMA) scheme. Applications under the MDS category are, on the other hand, message-oriented and expected to vary widely in characteristics; from simplex mode short messaging applications to long duration, full-duplex interactive data communication and large file transfer applications. For some applications under this service category, the conventional circuit-based DAMA scheme may prove highly inefficient due to the long time required to set up and establish communication links relative to the actual message transmission time. It is proposed that by defining a set of basic bearer services to be supported in MDS and optimizing their transmission and access schemes independent of the MTS and MRS services, the MDS applications can be more efficiently integrated into the multi-service design of mobile satellite systems.

INTRODUCTION

Mobile satellite systems (MSS) being planned for introduction early in the next decade are expected to support wide-area MTS, MRS, and MDS services. MTS and MRS will support voice communication applications, with subscribers in the MTS service allowed direct access to and from the public switched telephone network (PSTN) in much the same way as possible with terrestrial-based cellular mobile services. Gateway Stations are the ground segment network elements which will

interface MTS service subscribers to the PSTN.

MRS, on the other hand, will be tailored to private networks of closed user groups and will not provide direct access to the PSTN. A typical private MRS network will consist of a number of mobile user terminals and a single-channel Base Station through which communication links will be established. The Base Station will normally interface to the private organization's dispatch console or a PBX, as required in the individual application.

Plans for first generation MSS systems suggest that the MTS and MRS services will be provided through circuit-switched voice connections, under the control of a centralized DAMA system. Because of the high unevenness in the sources of traffic in a typical MRS network (i.e. several mobile terminals accessing a limited capacity Base Station), a large number of requests from mobile terminals will encounter blockage due to the Base Station being busy on another call. For this reason, the DAMA scheme for MRS service should ideally be capable of handling call attempts from mobile terminals on a blocked-calls-queued basis. The queuing in this case will be for establishing order in the processing of multiple requests to the same destination rather than as a means of handling lack of channels in the system.

MDS is intended to provide data communication capabilities between a customer's facility and mobile or portable terminals belonging to the same private network. A variety of data communication applications have been proposed for first generation MSS systems including, but not limited to: interactive digital messaging (including vehicle dispatch), paging, vehicle location, data acquisition and control, data collection, data broadcast, and bulk data transfer (data, image, text). Data Hubs are the network elements which have been designated to support applications under the MDS category. Typically, these facilities will be shared among many private data networks, with data links being established between the Hub station and individual organizations. Where required, access to public data networks (e.g. Datapac, Dataroute) will be provided through these stations.

Mobile and portable terminals will be developed to support applications under the three service categories. Although terminals for the MTS and MRS services are expected to be capable of in-band data transmission on a circuit-switched basis, applications falling under the MDS category are planned to be supported through data-only terminals with capability for operating on packet-switched connections. Different types of MDS terminals may be required to economically accommodate the anticipated wide range of data communication applications.

ALTERNATIVES FOR IMPLEMENTING THE MDS SERVICE

Unlike the MTS and MRS services, the networking plan and control facilities for supporting applications under the MDS service have, for the most part, not been clearly defined. Some proposals have been put forward to try to establish the manner in which these applications will be accommodated in the multi-service architecture of first generation MSS systems. A number of existing proposals appear to favour an

integrated approach to implementing the three services. The most popular ones are discussed below.

Use of a Common DAMA Scheme for Voice and Data Services

One alternative proposed for accommodating the MDS service is to use the control facilities of the MTS and MRS services to support the planned data communication applications. Under this option, MDS calls are handled in a similar fashion as voice calls, where a communication channel is assigned for each request and considered in use until relinquished by the parties on the channel.

Regardless of the criteria used to relinquish communication channels, there are some basic disadvantages to using DAMA-assigned channels for packet-based messaging. If connections are setup and torn down on a per-message basis, the overhead requirements will significantly lower the data handling capacity of the system. If, instead, connections are maintained on a per-session basis, too much idle time will result between successive transmissions. Furthermore, in systems where data services are provided through circuit-switched connections, service billing is generally based on the total channel holding time rather than on the volume of data transferred. This can be very expensive for some data users.

Use of Common Facilities for Voice and Data Calls

A variation of the above method is where data and voice calls are interspersed on the same set of available communication channels. Under this approach, data calls are assigned to idle communication channels on a single-transmission-per-request basis with preassigned transmission start and end times (i.e. using closed-end channels). Voice calls are assigned idle communication channels on an open-ended basis. A data call request which is received when all communication channels are in use carrying a mixture of open-ended and closed-end calls is queued up for a closed-end channel with the shortest delay, and assigned a transmission start time to permit completion of the data call.

Although this integrated approach has the potential to increase the overall communication channel utilization efficiency, complex timing manipulations will be required to handle applications where multi-packet transmissions from the same terminal are necessary or when packet errors occur. Further, if at any point in time the network experiences a high volume of voice traffic, data users will be blanked out or at least severely delayed. Likewise, a peak of high data traffic in the network could cause excessive delays for voice requests. For these reasons, the technique of integrating voice and data traffic in the manner described above may not suffice as a general purpose data communication algorithm to support the proposed MDS applications.

Use of Dedicated Facilities for MDS Applications

A more efficient way of accommodating MDS applications may be through use of dedicated facilities. In one such investigation, an adaptive DAMA scheme for integrated circuit- and packet-oriented services was proposed [Yan, 1986]. Under this

plan, the set of channels in the network is maintained in a pool which is functionally partitioned into sets of request, open-end, and closed-end channels. Voice and data call requests from mobile terminals are sent over the request channels, and the open-end and closed-end channels are assigned on demand to process circuit-oriented and packet-oriented calls, respectively. The partitioning of the available set of system channels is dynamically adjusted by the NCC to minimize the blocking probability of the voice traffic and the total average delay of the data traffic.

With most data messages in the MDS service expected to be short (in the order of 1 kbits), the inherent overhead associated with a DAMA scheme such as proposed will make the technique less efficient in the majority of applications. As well, as with any closed-end allocation scheme, there is the problem of handling errors. Closed-end assignments for data messaging work well only in an error-free channel. In a severe propagation environment such as to be expected in MSS [Lutz, 1986], some ARQ protocols will have to be employed. Messages will either have to be transmitted many times until received error-free, or a new reservation request be issued before each retransmission of an unreceived message. In one case message transmission times will have a large variance and call end times will be difficult to estimate, and in the other, additional channel set-ups and hence overheads will be involved, lowering the capacity of the data channel.

A DECENTRALIZED APPROACH TO PROVIDING THE MDS SERVICE

The majority of proposed MSS implementation schemes appear to try to optimize, on an integrated-services basis and simultaneously, the two sets of resource management problems; i.e. (i) partitioning of bandwidth for the different services, which must be changeable but does not require a high degree of dynamism; and (ii) real-time allocation of resources to users. An examination of the proposed applications indicates that integration of the three services under a common control scheme will at best result in inefficient utilization of channel resources and possibly increased customer dissatisfaction due to potentially long delays in accessing the network.

We therefore propose that the resource management problems be uncoupled such that bandwidth partitioning remains centrally controlled by the network management function at the NCC, but the real-time allocation of channel time in the MDS service is decentralized and managed by the Data Hubs. Further, considering that the many MDS applications could be more adequately and efficiently addressed through further categorization according to traffic characteristics, a set of bearer services is proposed to perform the transportation of data packets between mobile terminals and the Data Hubs. Channel access modes for each bearer service are then proposed to address the individual traffic characteristics and unique requirements of the services.

Proposed Bearer Services

We propose classifying MDS applications under three categories of bearer services:

- full-duplex (FDX) data service,
- inbound simplex (ISX) data service, and
- outbound simplex (OSX) data service.

The FDX service will encompass all two-way data communication applications, including interactive digital messaging, bulk data transmission, data acquisition and control, and vehicle dispatch. The ISX service will cover one-way data transmission applications such as vehicle tracking and location determination, and data collection from remote platforms. The OSX data service will cover point-to-multipoint data applications such as wide area paging and data broadcasting. Future applications can be classified as appropriate under the three bearer services.

Characterization of the Outbound Links

Because of the differences in characteristics among the bearer services, it is anticipated that optimum packet size requirements for the three services will differ. As such, for efficient utilization of the channels and in attempt to minimize the processing complexity at the terminal end, it is recommended that separate outbound channels be provided for the FDX and the OSX data services. These channels will operate in TDM mode, carrying control and synchronization information, and user traffic from the Data Hub. The outbound channel for the OSX data service may also be used to carry acknowledgement messages for the ISX service, if required.

Inbound Link for the Simplex Data Service

Data transmissions from terminals in the ISX service are expected to be of the single-packet type, although the required packet size is yet to be determined. As well, it is expected that traffic from any one data source will be low in volume and periodic in occurrence. Depending on the optimum packet length for applications under this bearer service, TDMA with very long frames may be used for the inbound link, or polling via an outbound channel. This channel may also be used to carry acknowledgement messages for the OSX data service, if required.

Inbound Link for the Full-Duplex Data Service

The FDX service is expected to handle potentially large volumes of data entering the system at infrequent and unscheduled times. For such applications, resource sharing approaches that use fixed allocation of capacity tend to be wasteful and inefficient. It is proposed that for better utilization of the channel resources, the inbound channel for the FDX service be operated with a reservation type multiple access scheme (e.g. reservation ALOHA, Demand-Assigned TDMA) controlled from the Data Hub.

Some duplex data applications may only require the transmission of single packet messages from the terminal end. For these, a contention type multiple access scheme (e.g. slotted ALOHA) may be used to avoid the overhead associated with reservation type schemes.

Network Registration Requirement for MDS Service Terminals

It should be noted that the proposed decoupling of resource management functions in the MDS service is in no way intended to isolate data service terminals from any control by the NCC. On initial power up, all MDS terminals will be required to log-in through the network signalling channel terminating at the NCC, just like the MTS and MRS service terminals. Upon recognizing a data terminal and verifying its validity, the NCC will direct the logged-in terminal to the appropriate data channel terminating at the Data Hub serving the user group. Only then will the terminal be allowed to use the network facilities for data transfers.

SUMMARY AND RECOMMENDATIONS

Applications that are planned to be supported under the MDS service category are many and widely varied in characteristics. An examination of implementation schemes proposed for integrating this service into the multi-service design of MSS systems indicates that no single scheme could adequately and efficiently perform as a general purpose algorithm to serve all applications. By uncoupling the satellite resource management problems and grouping the proposed data applications into three sets of bearer services, a more efficient approach to implementing the MDS service was described. It is recommended that the network-wide transponder bandwidth management function be left centralized at the NCC, but that the real-time allocation of channel time for MDS applications be decentralized and controlled from the Data Hubs.

Under this decentralized implementation proposal, it is further recommended that the FDX data service be provided using a reservation type multiple access scheme (e.g. DA-TDMA) for handling multi-packet messages, and a contention type access scheme (e.g. Slotted ALOHA) for applications using single-packet message transmissions from user terminals. The ISX data service, with single-packet, fairly periodic messaging requirements, may be efficiently accommodated using TDMA or polling, depending on the optimum packet length for this bearer service.

Application studies are currently under way to address the next level of design; i.e. examining specific MDS applications and how they would fit into the proposed bearer services. This will lead into the determination of optimum packet sizes, error control requirements, and expected traffic handling capacities of each service.

REFERENCES

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